GOLF CLUB HEAD AND METHOD OF FABRICATING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a golf club head and a method of fabricating the same, and more particularly to a golf club head has a faceplate with a modified sweet spot to cause a golf ball to travel a farther distance.

2. Description of Related Art

Types of golf clubs are woods, irons and putters. Each of them has a grip, a shaft and a head. The shaft has two ends. The grip is attached to one end of the shaft, and the head is attached to the other end of the shaft. The grip is used by a golfer to hold the club, and the head is used to hit balls. The head on a club with a longer shaft hits a ball a greater distance. To hit the ball powerfully and successfully, the head of the golf club is made of high strength material such as metal or composite materials.

Generally speaking, a golfer hits balls with a swing speed from 30 to 50 meters per second (m/s) with an impact duration of about 0.0045 second. To consistently ensure powerfully and successfully striking a ball, all conditions of the head must be stable. The club head has a face with a faceplate designed to make direct contact with a ball so increased stiffness of the faceplate can help the golfer strike a ball powerfully. Some methods for increasing the stiffness of the faceplate have been developed. One of them is to add ribs in the head to bear the force of impact when the head strikes the ball.

With reference to Fig. 9, a golf club head in accordance with the prior art includes an empty body (50), a crown empty member (51) and ribs (52). The

body (50) has a front side (not numbered), a rear side (not numbered), a face (501), a hosel (502) and a shank (503). The hosel (502) is defined in shank (503) and is adapted to attach to a shaft (60). The face (501) with a faceplate (not numbered) is attached to or formed on the body (50) at the front side and is adapted to hit the balls. The ribs (52) are mounted in the body (50) behind the faceplate of the face (501) to increase the stiffness of faceplate of the face (501) to hit the ball powerfully. The crown empty member (51) is attached to the body (50) at the rear side to cover the body (50). With reference Fig. 10, another conventional metal wood golf club head has a structure similar to the golf club head previously described. The metal wood golf club head has an empty body (50') with a faceplate (not numbered) and a spiral rib (52') mounted on the back of the faceplate of the body (50') to increase the stiffness of the faceplate.

Also, another way to increase the stiffness of the face is to attach a high strength, reinforced plate to the face of the head. With reference to Figs. 11 and 12, a reinforced plate (63) is attached to the face (501) attached to the body (50). The reinforced plate (63) has high strength and makes the face (501) thicker to increase the stiffness of the face (501).

Furthermore, increasing toughness of the faceplate of the face (501) will increase the impact duration and help the golfer to maintain ball velocity on off-center hits. The increased toughness will dampen harsh-feeling vibrational frequencies that occur at impact. However, the stiffness and the toughness of the same material are inversely proportional mechanical properties, which means if the stiffness is increased, the toughness will decrease.

To overcome the shortcomings, the present invention provides a golf

club head and method for fabricating the same to mitigate or obviate the aforementioned problems.

SUMMARY OF THE INVENTION

Generally, a golf club head includes a body and a faceplate. The body has a face adapted to hit balls and the faceplate is attached or formed firmly to the face of the body. The faceplate in accordance with the present invention has a center of percussion and a softened region. The center of percussion, called a "sweet spot," is the best point to hit the balls, and the softened region that is formed by a heat treatment technique is formed around the sweet spot of the faceplate. Thickness of the faceplate attached to the face of body of the golf club head is about 2.1 to 2.3 millimeters (mm). Tensile strength of the faceplate is required to be from 100 to 120 ksi (kilo-psi), and the higher, the better. The faceplate is generally made of high strength materials such as maraging steel, near β-phase titanium (Ti) alloy or the like.

Another factor that influences hitting the balls is called the coefficient of restitution or "COR" and relates to the energy transfer that occurs when the faceplate impacts a ball. COR directly relates to the speed of the ball as it rebounds from the faceplate. Generally, a faceplate with a higher COR will generate greater ball velocity that results in more distance.

For form the softened region, the heat treatment technique in accordance with the present invention comprises:

locating a copper tubing on a faceplate over the region to be softened;

applying a high-frequency current to the copper tubing to create a time-varying magnetic field which induces heat in the region of the faceplate to be

softened; and

removing the copper tubing from the softened region of the faceplate.

The softened region can increase the COR of the faceplate and cause a ball to travel a greater distance. Consequently, the faceplate has a high strength sweet spot and higher COR to hit the ball powerfully and successfully.

The main objective of the invention is to provide a golf club head with a high strength sweet spot and a softened region around the sweet spot to increase the COR of the golf club head to hit balls powerfully and successfully.

Another objective of the invention is to provide a heat treatment technique to form the softened region of the faceplate by applying a high-frequency current to a copper tubing that is positioned over the faceplate.

Other objectives, advantages and novel features of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1a is a perspective view of a metal wood golf club head in accordance with the present invention;

Fig. 1b is a perspective view of an iron golf club head in accordance with the present invention;

Fig. 2 is a schematic of a high-frequency induction heating machine that uses a high-frequency current heat treatment technique;

Fig. 3 is a top plan view showing a faceplate of the golf club head in Figs. 1 and 2 being annealed by a copper tubing of the high-frequency induction heating machine in Fig. 2;

Fig. 4 is a graph of the hardness of the sweet spot of the faceplate in Fig. 3 before heating and after heating;

Fig. 5 is a graph the skin depth of the high-frequency current for a specific frequency;

Fig. 6 is a graph of the output power as a function of the frequency of the high-frequency current;

Fig. 7 is a graph of the acting time that the high-frequency current required to be active as a function of the frequency of the high-frequency current;

Fig. 8 is a table of the results of impact test;

Fig. 9 is a cutaway exploded perspective rear view of a conventional a golf club head;

Fig. 10 is a cross sectional rear plan view of a conventional a metal wood golf club head;

Fig. 11 is a cross sectional side plan view of a conventional iron golf club head; and

Fig. 12 is a cross sectional side plan view of another conventional metal wood golf club head.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

With reference to Figs. 1a, 1b and 3, a golf club head (10) for an iron or a wood in accordance with the present invention includes a body (11) and a faceplate (12). The body (11) has a hosel (110), a face (111) and a shank (112). The hosel (110) is defined at the shank (112) and is adapted to connect to a shaft (not shown) of the golf club. The face (111) is formed on the body (11) and is

adapted to hit a golf ball (not shown). The face (111) may be a recess in which the faceplate (12) is mounted.

The faceplate (12) is attached firmly to or formed integrally on the face (111) of the body (11) by welding, forging or other means and has a center of percussion, called a "sweet spot," and a softened region (121). The sweet spot represents the spot of desired contact with the ball, and the softened region (121) is formed around the sweet spot by a heat treatment technique. The faceplate (12) is made out of high strength precipitation hardening stainless steel (typical of such stainless steel materials is 17-4PH (American Iron and Steel Institute, AISI. No. 630), AISI. No. 455 or 465), titanium (Ti) alloys (typical of such titanium alloys is Ti-6Al-4V, 15-3-3-3Ti, Ti-10V-2Fe-3Al, or Ti-20V-4Al-1Sn) or other high strength iron-based materials (typical of such iron-based materials is Fe-9Al-28Mn-1C-6Cr).

With reference to Fig. 2 and 3, the heat treatment technique to form the softened region (121) on the faceplate (12) uses a high-frequency induction heating machine. The high-frequency induction heating machine includes a power control box (20), a high-frequency current generator (21), a weight load (22), copper tubing (23) and a base (24). The faceplate (12) is mounted on the base (24), and the copper tubing (23) is positioned over the faceplate (12). The weight load (22) creates a force (F) perpendicular to the faceplate (12) to press the copper tubing (23) against the faceplate (12). The copper tubing (23) is electrically connected to the high-frequency current generator (21) that is controlled by the power control box (20). When the power control box (20) is turned on, the high-frequency current generator (21) generates a high-frequency

current and applies to the high-frequency current to the copper tubing (23). A time-varying magnetic field will be generated around the copper tubing (23), and magnetic flux of the magnetic field induces internal currents, as known as eddy currents, in the faceplate (12). Part of the magnetic energy will be lost, called eddy-current lose, which is converted to thermal energy to locally heat the faceplate (12) for annealing to form the softened region (121) in the faceplate (12) under the copper tubing (23).

With reference to Fig. 5, skin depth represents the depth at which the eddy current density induced in the faceplate (12) by the high-frequency current works is sufficient to anneal the metal in the faceplate (12). As the frequency of the high-frequency current increases, the skin depth is shallower. This phenomenon is called "skin effect". With reference to Fig. 6, as the frequency of the high-frequency current increases, the output power of the high-frequency current increases, too. This phenomenon is used to heat the metal to a required temperature for annealing in a very short time with a large output power. With reference to Fig. 7, when the output power of the high-frequency current is large, the acting time is short.

Therefor, the thermal energy converted from the magnetic energy is a function of the frequency and the output power of the high-frequency current and the acting time. For example, a high-frequency current with 80 kilowatts of output power is applied to a faceplate (12), which is made of titanium alloy (Ti-20V-4Al-1Sn) for 8 seconds. When the high-frequency current is applied to the copper tubing (23) that heats the faceplate (12) around the sweet spot, the grain structure of the softened region (121) is changed by the heat, and the mechanical

properties of the softened region (121) are different from the other area. After the heat acts on the metal, the grain size of the softened region (121) becomes 2 to 4 times larger than before. With reference to Fig. 4, wherein the distance represents a width of the softened region (121) on the faceplate (12), the unheated faceplate (12) has a uniform hardness (A). After heating the faceplate (12), the hardness (B) of the faceplate (12) varies around the sweet spot, and a hardness difference between the softened region (121) and the sweet spot is from 20 to 22 H_RC.

Based on experimental result, some best control conditions for processing the faceplate (12) with a thickness from 2.1 to 2.3 mm are summed up as follows.

1. The frequency of the high-frequency current is 50 to 2000 Hz.

2. The output power of the high-frequency current is 10 to 150 kilowatts.

3. The high-frequency current is applied for 0.5 to 10 second(s).

4. An outer diameter of the copper tubing (23) is 3 to 8 millimeters.

5. A distance between the copper tubing (23) and the faceplate (12) is 1.5 to 3 millimeters.

With reference to Fig. 8, impact tests were performed to confirm the improvement in the coefficient of restitution (COR) effects of the present invention to the faceplate (12).

From items 1 to 5 in Fig. 8, the faceplate (12) is made of titanium alloy (Ti-20V-4Al-1Sn), and attached to the face of the head of a driver (No.1 wood) with a 9.5-degree launch angle, and a volume of the head is 400 cubic centimeters (cc).

From items 6 to 10 in Fig. 8, the faceplate (12) is made of maraging steel (AISI. No. 465), and attached to the face of the head of a driver (No.1 wood) with a 9.5-degree launch angle, and a volume of the head is 310 cubic centimeters (cc).

From items 11 to 15 in Fig. 8, the faceplate (12) is made of Fe-base materials (Fe-9Al-28Mn-1C-6Cr), and attached to the face of the head of a driver (No.1 wood) with a 9.5-degree launch angle, and a volume of the head is 320 cubic centimeters (cc).

From items 16 to 20 in Fig. 8, the faceplate (12) is made of stainless steel (17-4PH), and attached to the face of the head of a driver (No.1 wood) with a 9.5-degree launch angle, and a volume of the head is 270 cubic centimeters (cc).

The test results clearly show that the coefficient of restitution (COR) of the faceplate (12) is improved after the heating treatment technique is performed. Items 5, 10, 15 and 20 show another interesting result that excessive heating will decrease the COR of the faceplate (12). Therefor, keeping the control conditions within the limits shown above is important when processing the faceplate (12).

From the above description, the present invention can really not improve the coefficient of restitution of the golf club head to hit the ball successfully but retain the strength of the sweet spot of the golf club head to hit the ball powerfully.

Even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and

arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.